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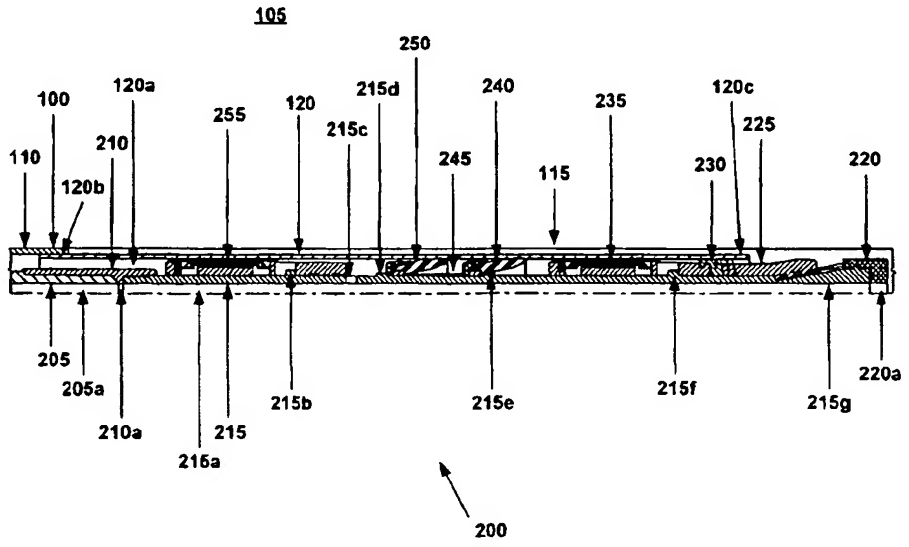
(54) Title: ADJUSTABLE EXPANSION CONE ASSEMBLY



(57) Abstract: An adjustable expansion cone assembly.

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 166/380,207,378, 212, 217, 242.6

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,420,866 A (MUELLER) 20 December 1983 (20.12.83), figures 1-4.	34-79

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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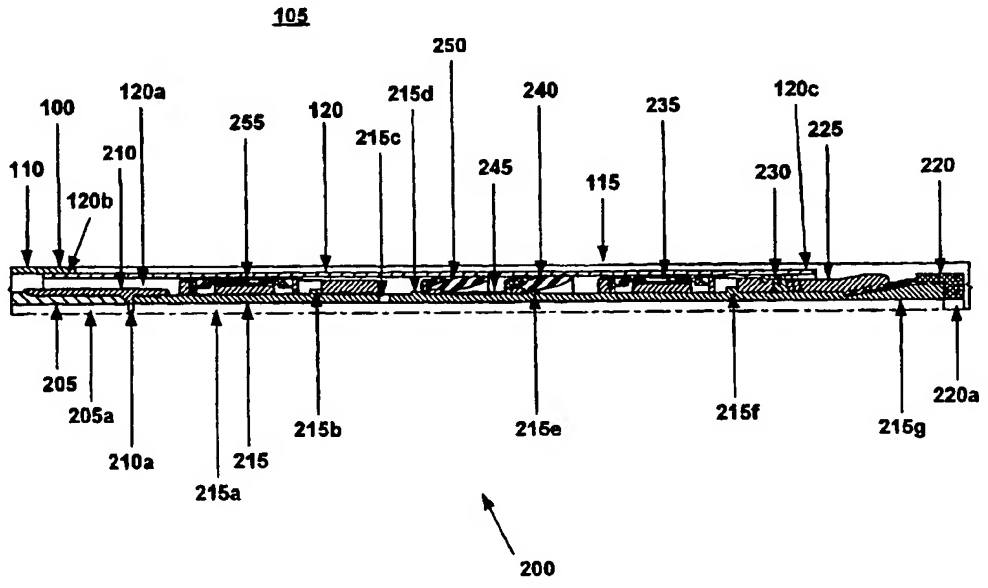

(57) Abstract: An adjustable expansion cone assembly.

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AMENDED CLAIMS

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means for increasing the outside diameter of the adjustable expansion cone assembly by displacing the actuator and the adjustable expansion cone assembly relative to the expandable tubular member in a second direction opposite to the first direction.

78. The apparatus of claim 77, wherein the means for displacing the actuator of the apparatus in the first direction comprises:

means for impacting the actuator.

79. The apparatus of claim 77, wherein the means for displacing the actuator and the adjustable expansion cone assembly relative to the expandable tubular member in the first direction comprises:

means for impacting the actuator.

80. A method of radially expanding and plastically deforming a tubular member, comprising;

radially expanding at least a portion of the tubular member by increasing an operating pressure of a volume of a fluidic material contained by at least a portion of the tubular member; and

radially expanding and plastically deforming at least a portion of the tubular member by displacing an expansion device within the tubular member.

81. The method of claim 80, wherein the volume comprises an annular volume.

82. The method of claim 80, wherein the expansion device is controllably adjustable from a first outside diameter to a second outside diameter.

83. An apparatus for radially expanding a tubular member, comprising:

a tubular support member;

an adjustable expansion device movably coupled to the tubular support member; and

means for adjusting the adjustable expansion device.

84. The apparatus of claim 83, wherein the means for adjusting the adjustable expansion device comprises:

frictional means for adjusting the adjustable expansion device.

85. The apparatus of claim 83, wherein the means for adjusting the adjustable expansion device comprises:

resilient means for adjusting the adjustable expansion device.

86. An adjustable expansion device, comprising:

a tubular support member;

an adjustable expansion device movably coupled to the tubular support member, comprising:

a plurality of expansion segments; and

means for guiding the expansion segments on the tubular support member; and

means for adjusting the adjustable expansion device.

87. The adjustable expansion device of claim 86, wherein the adjustable expansion device further comprises:

means for interlocking the expansion segments.

88. The adjustable expansion device of claim 86, wherein the means for adjusting the adjustable expansion device comprises:

resilient means for supporting the expansion segments.

89. The adjustable expansion device of claim 86, wherein the expansion segments include first and second interleaved groups of expansion segments.

90. The adjustable expansion device of claim 89, wherein the means for adjusting the adjustable expansion device comprises:

means for displacing the first and second interleaved groups of expansion segments in opposite directions.

91. A method of operating an adjustable expansion device comprising a plurality of expansion segments, comprising:

guiding the expansion segments on a tapered body; and

controllably displacing the expansion segments along the tapered body.

92. The method of claim 91, further comprising:

resiliently guiding the expansion segments on the tapered body.

93. The method of claim 91, further comprising:

interlocking the expansion segments.

94. The method of claim 91, further comprising:

dividing the expansion segments into first and second groups of expansion segments; and

interleaving the first and second groups of expansion segments.

95. The method of claim 94, further comprising:

overlapping the first and second groups of expansion segments.

96. The method of claim 94, wherein controllably displacing the expansion segments along the tapered body comprises:

displacing the first and second interleaved groups of expansion segments in opposite directions.

97. A method of operating an adjustable expansion device comprising a plurality of expansion segments, comprising:

guiding the expansion segments on a multi-sided tapered body;

interlocking the expansion segments; and

controllably displacing the expansion segments along the tapered body.

98. A method of operating an adjustable expansion device comprising a plurality of expansion segments, comprising:

resiliently guiding the expansion segments on a multi-sided tapered body;

guiding each of the expansion segments on opposite sides in the circumferential direction;

interlocking the expansion segments; and

controllably displacing the expansion segments along the tapered body.

99. A method of operating an adjustable expansion device comprising a plurality of expansion segments, comprising:

dividing the expansion segments into first and second groups of expansion segments;

interleaving the first and second groups of expansion segments;

overlapping the first and second groups of expansion segments;

resiliently guiding the expansion segments on a multi-sided tapered body;

guiding each of the expansion segments on opposite sides in the circumferential direction; and

controllably displacing the expansion segments along the tapered body.

100. A method of operating an adjustable expansion device comprising a plurality of expansion segments, comprising:

dividing the expansion segments into first and second groups of expansion segments;

interleaving the first and second groups of expansion segments;

guiding the expansion segments on a multi-sided tapered body; and

controllably displacing the expansion segments along the tapered body while also relatively displacing the first and second groups of expansion segments in opposite directions.

101. A method of plastically deforming and radially expanding an expandable tubular member using an apparatus comprising a tubular support member, an adjustable expansion device movably coupled to the tubular support member, and an actuator movably coupled to the tubular support member for adjusting the adjustable expansion device, comprising:

coupling a first end of the expandable tubular member to a tubular structure;

locking the actuator to the tubular support member of the apparatus;

inserting the apparatus into the first end of the expandable tubular member;

moving the actuator and the adjustable expansion device of the apparatus out of the second end of the expandable tubular member;

reinserting the actuator of the apparatus into the second end of the expandable tubular member;

unlocking the actuator from the tubular support member of the apparatus;

rotating the actuator relative to the tubular support member of the apparatus; and

increasing the outside diameter of the adjustable expansion device by moving the tubular support member relative to the actuator, the adjustable expansion device, and the expandable tubular member; and

plastically deforming and radially expanding the expandable tubular member by moving the adjustable expansion device through the expandable tubular member.

102. The method of claim 101, wherein the tubular support member includes one or more lugs; wherein the actuator includes one or more corresponding retaining slots; and wherein locking comprises positioning the lugs into the corresponding retaining slots.

103. The method of claim 101, wherein the tubular support member includes one or more lugs; wherein the actuator includes one or more corresponding retaining slots; and wherein unlocking comprises positioning the lugs out of engagement with corresponding retaining slots.

104. The method of claim 101, wherein moving the tubular support member relative to the actuator, the adjustable expansion device, and the expandable tubular member comprises:

the actuator frictionally engaging the expandable tubular member.

105. The method of claim 101, wherein moving the adjustable expansion device through the expandable tubular member comprises:

pulling the adjustable expansion device through the expandable tubular member.

106. The method of claim 101, further comprising:

fluidicly sealing the interface between the tubular support member of the apparatus and the expandable tubular member;

wherein moving the adjustable expansion device through the expandable tubular member comprises:

injecting a pressurized fluid into the tubular support member.

107. A method of plastically deforming and radially expanding an expandable tubular member using an apparatus comprising a tubular support member, an adjustable expansion device movably coupled to the tubular support member, and an actuator movably coupled to the tubular support member for adjusting the adjustable expansion device, comprising:

coupling a first end of the expandable tubular member to a tubular structure;

inserting the apparatus into the first end of the expandable tubular member in a first direction;

displacing the actuator of the apparatus in a second direction opposite to the first direction;

applying a resilient biasing force to the adjustable expansion device in the second direction;

moving the actuator and the adjustable expansion device of the apparatus out of the second end of the expandable tubular member;

reinserting the actuator of the apparatus into the second end of the expandable tubular member in the second direction;

increasing the outside diameter of the adjustable expansion device by displacing the actuator and the adjustable expansion device relative to the expandable tubular member in the first direction; and

plastically deforming and radially expanding the expandable tubular member by moving the adjustable expansion device through the expandable tubular member in the second direction.

108. The method of claim 107, wherein displacing the actuator of the apparatus in the second direction comprises:

impacting the actuator with the first end of the expandable tubular member.

109. The method of claim 107, wherein displacing the actuator and the adjustable expansion device relative to the expandable tubular member in the first direction comprises:

impacting the actuator with the second end of the expandable tubular member.

110. The method of claim 107, wherein moving the adjustable expansion device through the expandable tubular member comprises:

pulling the adjustable expansion device through the expandable tubular member.

111. The method of claim 107, further comprising:

fluidicly sealing the interface between the tubular support member of the apparatus and the expandable tubular member;

wherein moving the adjustable expansion device through the expandable tubular member comprises:

injecting a pressurized fluid into the tubular support member.

112. An adjustable expansion device, comprising:

a plurality of expansion segments;

means for guiding the expansion segments on a tapered body; and

means for controllably displacing the expansion segments along the tapered body.

113. The assembly of claim 112, further comprising:

means for resiliently guiding the expansion segments on the tapered body.

114. The assembly of claim 112, further comprising:

means for interlocking the expansion segments.

115. The assembly of claim 112, further comprising:

means for dividing the expansion segments into first and second groups of expansion segments; and

means for interleaving the first and second groups of expansion segments.

116. The assembly of claim 115, further comprising:
means for overlapping the first and second groups of expansion segments.

117. The assembly of claim 115, wherein the means for controllably displacing the expansion segments along the tapered body comprises:
means for displacing the first and second interleaved groups of expansion segments in opposite directions.

118. An adjustable expansion device, comprising:
a plurality of expansion segments;
means for guiding the expansion segments on a multi-sided tapered body;
means for interlocking the expansion segments; and
means for controllably displacing the expansion segments along the tapered body.

119. An adjustable expansion device, comprising:
a plurality of expansion segments;
means for resiliently guiding the expansion segments on a multi-sided tapered body;
means for guiding each of the expansion segments on opposite sides in the circumferential direction;
means for interlocking the expansion segments; and
means for controllably displacing the expansion segments along the tapered body.

120. An adjustable expansion device, comprising:
a plurality of expansion segments;
means for dividing the expansion segments into first and second groups of expansion segments;
means for interleaving the first and second groups of expansion segments;
means for overlapping the first and second groups of expansion segments;
means for resiliently guiding the expansion segments on a multi-sided tapered body;
means for guiding each of the expansion segments on opposite sides in the circumferential direction; and
means for controllably displacing the expansion segments along the tapered body.

121. An adjustable expansion device, comprising:
a plurality of expansion segments;
means for dividing the expansion segments into first and second groups of expansion segments;
means for interleaving the first and second groups of expansion segments;
means for guiding the expansion segments on a multi-sided tapered body; and
means for controllably displacing the expansion segments along the tapered body while also relatively displacing the first and second groups of expansion segments in opposite directions.

122. An apparatus for plastically deforming and radially expanding an expandable tubular member, comprising:

a tubular support member;

an adjustable expansion device movably coupled to the tubular support member;

means for actuating the adjustable expansion device;

means for locking the actuator to the tubular support member of the apparatus;

means for unlocking the actuator from the tubular support member of the apparatus;

means for increasing the outside diameter of the adjustable expansion device by moving the tubular support member relative to the actuator, the adjustable expansion device, and the expandable tubular member.

123. The apparatus of claim 122, wherein the tubular support member includes one or more lugs; wherein the actuator includes one or more corresponding retaining slots; and wherein the means for locking comprises positioning the lugs into the corresponding retaining slots.

124. The apparatus of claim 122, wherein the tubular support member includes one or more lugs; wherein the actuator includes one or more corresponding retaining slots; and wherein the means for unlocking comprises positioning the lugs out of engagement with corresponding retaining slots.

125. The method of claim 122, further comprising:

means for fluidicly sealing the interface between the tubular support member of the apparatus and the expandable tubular member.

126. An apparatus for plastically deforming and radially expanding an expandable tubular member, comprising:

a tubular support member;

an adjustable expansion device movably coupled to the tubular support member;

means for actuating the adjustable expansion device;

means for displacing the actuator of the apparatus in a first direction;

means for applying a resilient biasing force to the adjustable expansion device when the actuator is displaced in the first direction;

means for increasing the outside diameter of the adjustable expansion device by displacing the actuator and the adjustable expansion device relative to the expandable tubular member in a second direction opposite to the first direction.

127. The apparatus of claim 126, wherein the means for displacing the actuator of the apparatus in the first direction comprises:

means for impacting the actuator.

128. The apparatus of claim 126, wherein the means for displacing the actuator and the adjustable expansion device relative to the expandable tubular member in the first direction comprises:

means for impacting the actuator.

129. An apparatus for radially expanding a tubular member, comprising:

a tubular support member;

an adjustable expansion cone assembly movably coupled to the tubular support member; and

means for adjusting the adjustable expansion cone assembly;

wherein the adjustable expansion cone assembly comprises one or more rigid moveable expansion cone segments.

130. An adjustable expansion cone assembly, comprising:

a tubular support member;

an adjustable expansion cone movably coupled to the tubular support member, comprising:

a plurality of rigid expansion cone segments; and

means for guiding the rigid expansion cone segments on the tubular support member; and

means for adjusting the adjustable expansion cone.

131. A method of operating an adjustable expansion cone assembly comprising a plurality of rigid expansion cone segments, comprising:

guiding the rigid expansion cone segments on a tapered body; and

controllably displacing the rigid expansion cone segments along the tapered body.

132. A method of operating an adjustable expansion cone assembly comprising a plurality of rigid expansion cone segments, comprising:

guiding the rigid expansion cone segments on a multi-sided tapered body;

interlocking the rigid expansion cone segments; and

controllably displacing the rigid expansion cone segments along the tapered body.

133. A method of operating an adjustable expansion cone assembly comprising a plurality of rigid expansion cone segments, comprising:

resiliently guiding the rigid expansion cone segments on a multi-sided tapered body;

guiding each of the rigid expansion cone segments on opposite sides in the circumferential direction;

interlocking the rigid expansion cone segments; and

controllably displacing the rigid expansion cone segments along the tapered body.

134. A method of operating an adjustable expansion cone assembly comprising a plurality of rigid expansion cone segments, comprising:

dividing the rigid expansion cone segments into first and second groups of rigid expansion cone segments;

interleaving the first and second groups of rigid expansion cone segments;
overlapping the first and second groups of rigid expansion cone segments;
resiliently guiding the rigid expansion cone segments on a multi-sided tapered body;
guiding each of the rigid expansion cone segments on opposite sides in the circumferential direction; and
controllably displacing the rigid expansion cone segments along the tapered body.

135. A method of operating an adjustable expansion cone assembly comprising a plurality of rigid expansion cone segments, comprising:
dividing the rigid expansion cone segments into first and second groups of expansion cone segments;
interleaving the first and second groups of expansion cone segments;
guiding the expansion cone segments on a multi-sided tapered body; and
controllably displacing the expansion cone segments along the tapered body while also relatively displacing the first and second groups of expansion cone segments in opposite directions.

136. An adjustable expansion cone assembly, comprising:
a plurality of rigid expansion cone segments;
means for guiding the rigid expansion cone segments on a tapered body; and
means for controllably displacing the rigid expansion cone segments along the tapered body.

137. An adjustable expansion cone assembly, comprising:
a plurality of rigid expansion cone segments;
means for guiding the rigid expansion cone segments on a multi-sided tapered body;
means for interlocking the rigid expansion cone segments; and
means for controllably displacing the rigid expansion cone segments along the tapered body.

138. An adjustable expansion cone assembly, comprising:
a plurality of rigid expansion cone segments;
means for resiliently guiding the rigid expansion cone segments on a multi-sided tapered body;
means for guiding each of the rigid expansion cone segments on opposite sides in the circumferential direction;
means for interlocking the rigid expansion cone segments; and
means for controllably displacing the rigid expansion cone segments along the tapered body.

139. (Original) An adjustable expansion cone assembly, comprising:
a plurality of rigid expansion cone segments;
means for dividing the rigid expansion cone segments into first and second groups of expansion cone segments;
means for interleaving the first and second groups of rigid expansion cone segments;

means for overlapping the first and second groups of rigid expansion cone segments;

means for resiliently guiding the rigid expansion cone segments on a multi-sided tapered body;

means for guiding each of the rigid expansion cone segments on opposite sides in the circumferential direction; and

means for controllably displacing the rigid expansion cone segments along the tapered body.

140. An adjustable expansion cone assembly, comprising:

a plurality of rigid expansion cone segments;

means for dividing the rigid expansion cone segments into first and second groups of expansion cone segments;

means for interleaving the first and second groups of rigid expansion cone segments;

means for guiding the rigid expansion cone segments on a multi-sided tapered body; and

means for controllably displacing the rigid expansion cone segments along the tapered body while also relatively displacing the first and second groups of rigid expansion cone segments in opposite directions.